To Overcome Challenges in Technology Development in Support of C2 through Social Learning

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ABSTRACT

Developing technology isn't always easy. Developing information and communication technology in support of C2 appears to be especially difficult. The origin of these difficulties can be traced back to two key challenges, namely: to the alignment of user needs with technical capabilities, and to the timely discovery and understanding of the impact those technologies have on the C2 domain.

This paper is about how we successfully can overcome these challenges. It will show that understanding these two challenges is crucial to achieve success in technology development. It will also show that the resolution of these challenges requires learning. Learning about C2 user-requirements, about capabilities of technology and about how both interact in the C2 user domain.

After decades of research in the field of technology assessment (TA), learning and understanding the interaction of users-needs and technology has proven to be fundamental to successful technology development. Furthermore, its importance is becoming more and more recognized in the field of C2 assessment and development as well, as is shown by Mandeles, Hone and Terry [1996]. Based on insights from constructive technology assessment (CTA) I have developed a model that facilitates learning in technology development. Furthermore, it especially addresses the two key challenges – alignment and timely impact assessment – to the successful development of technology in support of C2.

The NATO code of best practice for C2 assessment (COBP) plays an important role in this model. C2 is still a rather diffuse and complex concept. Yet, if we want to be successful in technology development the articulation of C2 user-needs is crucial. The COBP provides a structure for rigorous discovery and articulation of C2 user-needs. As such it could play an important role in achieving success in developing technology in support of C2.

The model and the COBP do not provide utopia, but they do provide us with a means to overcome the challenges in developing effective technology in support of C2.

Key Words*: Technology Development, Social Learning, Technology Assessment, Reciprocal Relationships.*

1.0 INTRODUCTION

Developing technology that will effectively support C2 requires learning. It requires learning about user-needs in C2 and about the capability of technology to fulfill those needs. To date that learning them

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has not been as effective as it could have been. This argument could be supported by an awareness that despite the fact that warfare is centuries old, and despite the writings of Sun Tzu and Von Clausewitz, we are still grappling to understand command and control and how technological developments affect it. This makes it difficult to successfully develop technology that fits as closely as possible the requirements of C2 operatives (i.e. commanders and staff). We are learning, but is it enough? And is our learning effective? Because already new technologies like nano technology or genetic technologies have appeared at the horizon and if we are not ready to meet them pitfalls like stove-piping may happen all over again.

The past years have shown that we can develop astonishing, exiting and inspiring new technological artifacts (e.g. Satcom, GPS, GSM, world wide internet, micro RPV's), yet matching technical capabilities effectively with user requirements often remains elusive and difficult to achieve. The results have been C2 systems that work, but do not, or not effectively, fulfill the tasks and requirements set by users (i.e. commanders and staff). In effect these technologies do not effectively support C2 operations. See for example the USAF information support systems during Desert Storm which where not up to the task [Mandeles et all. 1996]. The system worked because the officers quickly learned to bypass the system. Developing effective technology[1] requires achieving successful alignment between (real) user requirements and (real) technical capabilities, and in turn this requires a sound understanding of the user domain, of the technology, and of how these can be matched in the development of effective technology. In other words it requires an understanding of both the *content* and the *process* of technology development.

Linked to the need for alignment of needs and capabilities is the need to understand the impact of a technological artifact on an application domain into which it is introduced. Remember for example the effect of armor and airplane on warfare, or the impact of telegraphy, telephony and radio. Understanding the impact of a technology is necessary if we want to avoid unnecessary and unwanted (negative) consequences, and if we want to take effective preparations, for example to adapt training programs, organization structure or doctrine to the new technology. The US uses an acronym – DOTMLS[2] – that points at these preparations. While the acronym covers useful domains, it does not tell us how a technology will impact on a given application domain; it cannot tell us how to adapt nor what we need adapt to. To discover and understand how and to what we need to adapt we need to understand how technology interacts with its users in a given application domain. More precisely it requires knowledge about the reciprocal relationships between technology, organization and human behavior in the application domain.

In essence what the previous two paragraphs say is that successful technology development depends on *learning* and that this is related to the content and to the process of technology development.

Experience from the field of constructive technology assessment (CTA) states it more strongly and says that learning is crucial for successful development of effective technology [Smit and van Oost 2000]. Its position is that a priori neither a correct solution nor a correct development strategy exists in technology development. However much we know, each development is different, however small, from other developments. For example because of slightly different requirements, or a difference in operational environments. So finding the right solution depends on learning, learning about user-requirements, about technological capabilities, about how to achieve alignment, and about how to discover impacts. Still the question remains how can we learn this, and perhaps more importantly how can we assess if we are learning the right thing?

[1] Effective development is here defined as a process of technology development that results in technology (tanks, airplanes, ICT) that is functional in its application domain (military operations). It implies that capabilities, limitations and impact of that technology are understood. And it assumes that lessons learned from operations and technology development are implemented.

[2] DOTMLS stands for doctrine, organization, training, materiel, leadership, and soldiers [TRADOC 1997].

The answer to this question will be the topic for the remainder of this paper.

2.0 A CTA PERSPECTIVE ON LEARNING

There are several perspectives from which learning can be approached. For example form a psychological or pedagogic perspective, highlighting cognitive and educational aspects of learning respectively. However I will use the perspective of constructive technology assessment (CTA) because I want to focus on learning about the development of effective technology [Smit and van Oost 2000].

Constructive technology assessment [Rip, Misa and Schot 1995] is a paradigm or analytic approach in the field of technology assessment (TA) and science and technology studies (STS) [Jasanof et al.1995]. It differs from other TA paradigms in that it not only develops concepts that improve our understanding of dynamics in technology development, but also develops instruments to improve technology development in practice. This paper presents one such instrument.

An important fundament of CTA is the awareness that success in technology development is neither determined solely by technical nor by sociological factors, but is dependent on (understanding) the reciprocal interplay of technical and sociological factors, commonly referred to as socio-technical aspects of development [Smit and Van Oost 2000]. This can be illustrated by comparing two attempts to develop an information system for the Royal Netherlands Army (RNLA) field artillery, VERDAC and VUIST[3]. During the development of VERDAC[4] miscommunication and mistrust grew over time without any corrective measures being taken. This disrupted the interaction between developers and the RNLA field artillery so much so that technical challenges could not be resolved. After the failure of VERDAC the development of VUIST[5] was started in another attempt to develop a digital wireless CISS for the RNLA field artillery. Initially the same type of social disruption occurred. However, in this instance the RNLA and the developers were able to address the frictions within their interaction. This laid the fundament for improvements in the development process that resulted in the successful development and operational deployment [Wijdemans & Mancke 1995] of VUIST.

Figure (1) represents a graphical representation of VUIST. It depicts the digital network components that links (form right to left) the forward observer to the command and control information system, and through it to the field artillery gun/MRLS batteries [courtesy RNLA, IBT VUIST].

[3] Both cases of technology development have been used to explore and structure the development of an instrument to assess the effect and effectiveness of social learning in technology development.

[4] VERDAC is a Dutch acronym for ‘improved digital artillery computer”. Its development took place between 1982 and 1987. Though it resulted in a workable system the RNLA decided that it did not match the requirements closely enough and halted the development. The intriguing aspect of this was that VERDAC was the result of a collaborative effort between industry and the RNLA, and had started with a collaborative pre-development study six years before. Yet even so successful alignment didn’t seem possible.

[5] VUIST is a Dutch acronym for ‘fire support information system’. Its development took place between 1989 and 2000 and is currently fielded by the RNLA Field Artillery.

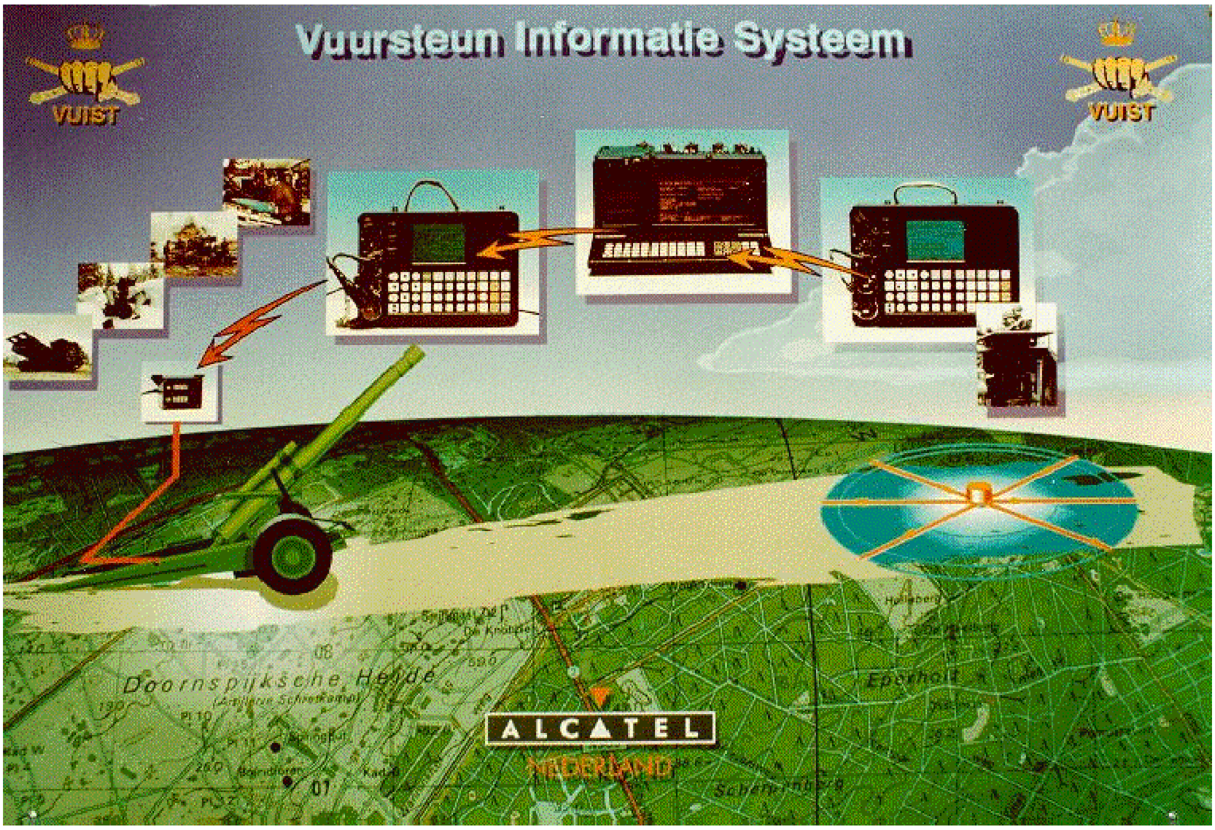

Figure 1: VUIST.

A second fundament is the awareness that successful development means that user requirements and technological capabilities are to be aligned, i.e. that the technology is able to perform effectively those tasks and functions that are required in an operational context. Successful alignment usually requires knowledge of both the user domain and technology domain. Furthermore, successful alignment requires also an understanding of how technology affects the user domain, i.e. an ability to assess if alignment is reached. This is closely coupled to a third fundament that states that it is preferable, often necessary, to discover and identify the consequences of the newly developed technology as early as possible. Most often these impacts are not well understood at the start of the development of new technologies, or how to discover them. Both have to be learned, namely through research or experimentation.

As the complexity of the world around us grows, it becomes more and more unlikely that one person knows it all. Sharing knowledge thus becomes an important part of technology development. It follows that learning in technology development also has to be a social process. It is a special type of learning that takes place in the interaction between players involved in the development of a technology. This is the reason that I refer to this type of learning as *social learning*. In the remainder of this paper I will zoom in on the interaction between intended-users (e.g. commanders and staff officers) and developers of a technology.

3.0 SOCIAL LEARNING: FOUR BUILDING BLOCKS

From a CTA perspective, learning in technology development involves four analytically distinct activities – *articulation*, *reflection*, *feedback* and *embedding of lessons learned* – though in practice the boundaries between them are less distinct and these activities may overlap from time to time.

3.1 Social Learning: Articulation

Articulation is in essence about making ones ideas and thoughts *explicit* and *specific*, so that others may know what you want or know how you perceive a situation to be. Articulation allows others to look at your ideas so that they can learn about them and reflect on them. Only when ideas, or needs for that matter, are made explicit and specific can they be transferred to others, and be discussed.

In technology development clear articulation of user needs (demand articulation) and of technical capabilities (supply articulation) are two very important types of articulation. Without the articulation of user requirements developers do not know how or what they should develop in response to user needs, and without effective knowledge of the operational context their own ideas often do not conform with user expectations. On the other hand users need to have a realistic assessment about the capabilities of a technology. Without it they are most often unable to define realistic requirements that could be fulfilled by technology.

Its importance can also be illustrated by experiences from the development of VUIST. Originally the specification of software requirements did not state in enough detail what the software should do nor how it should be done. (I.e. the demand articulation and technical articulation were not clear, nor specific enough). This made assessment of the alignment between developed software and requirements very difficult. It also led to friction between the RNLA members of the development team and the developers (from Elbit), which in turn almost destroyed their ability to exchange information about their respective knowledge domains (i.e. RNLA field artillery operations & information communication support systems). If they had allowed that situation to continue, alignment would have been impossible to achieve. In practice the participants realized their predicament and resolved the situation by addressing the friction between them in an open en frank manner, closely followed by the articulation of a common strategy for achieving alignment. Part of this strategy was to produce two booklets that became later part of the contract. The first contained the specifications of all the software requirements and improvements, the second contained the specification of how all these requirements would be implemented by the software (technology). These clear articulations facilitated mutual understanding and improved collaboration. In interviews held afterwards, these booklets, and thus articulation, were seen as fundamental to the successful development of VUIST, precisely because they improved communication and mutual understanding.

3.2 Social Learning: Reflection

Reflection in effect is evaluating your activities (which include developing concepts and decision making), or more specifically about the consequences of those activities. Reflecting in this sense is learning about what your activities have achieved, about how you did it, and about if you are content with the results (i.e. the ‘what’ and the ‘how’). Taking time to reflect allows you to evaluate the direction and process of development. Doing this regularly during the development process will not only allow you to monitor the development of technology more closely, but also monitor the process of development – i.e. the ‘what’ and ‘how’ in the development process. Doing this regularly enables you to assess if you have to intervene or change early in and during the development itself. Usually that is much better than discovering afterwards that the technology as developed has faults that could have been corrected if timely intervention had taken place.

The development of VUIST can be used to illustrate this point. VUIST was developed in what could be called a ‘trial & develop stage’ and a ‘develop & production stage’[6]*. The ‘trial & develop’ stage was used to discover whether VUIST was a viable system that could perform the required tasks and functions.*

[6] These two stages did happen, but their name as given in this paper is only meant to identify them in this paper.

Its viability was to be shown in an Operational Test scheme. If this test proved successful VUIST would be further developed and produced for operational use with the RNLA field artillery.

However, the period of the Operational Test was used not only to reflect on the viability of VUIST, but also on the viability of the development process itself. As a result the test procedures in the development stages were changed. In the first stage testing was performed independently by the RNLA and Elbit respectively, though observers could be present. Furthermore there was no common understanding of how this testing should be done, each followed its own rules. This meant that test results (or procedures) of one could not be subjected to rigorous assessment by the other. In practice this meant a loss of effective communication and even miscommunication. If allowed to continue this could easily have led to further misunderstanding or decrease in trust, in effect to a breakdown in development.

In the second stage the tests in development were performed simultaneously by a representative of both the RNLA and Elbit, following a commonly agreed upon scenario. In this procedure each 'error' in the software of VUIST would be the subject of assessment by both representatives, with regard to operational and software development consequences. Both the 'error' and the result of common assessment would be noted in a report. Each day after completion of the test, each 'error' and assessment result was evaluated simultaneously by a senior representative of the RNLA and of Elbit.

Together with the two booklets mentioned in the previous example on articulation, this reflective procedure proved to be effective in acquiring and improving alignment. It also aided in improving mutual understanding and trust.

3.3 Social Learning: Feedback and Embedding of Lessons Learned

<u>*Feedback*</u> in this context means the transfer of lessons learned in development to others involved in the development process. These lessons might be both about the content (e.g. the software used in VUIST, or experience with VUIST) and about the process (e.g. how the software was developed in VUIST). Furthermore, this feedback is relevant both internal to the development process (e.g. feedback from VUIST-users) and external to the development process (e.g. to other development projects).

Feedback like articulation and reflection is an important part of learning, because without acting on understanding gained no learning in technology development would take place [Shrivastava 1983, Fiol and Lyles 1985]. Just the acquisition of knowledge does not automatically lead to the goal of learning, namely improving the effectiveness of technology development. On the other hand, just taking action or changing procedures doesn't necessarily mean that learning takes place. For example a change in procedure does not necessarily have a positive effect on development, nor is every change accompanied or based on an improved understanding of development [after Tjepkema 1993]. At the same time both articulation and reflection are also an integral part of the feedback process. That is because lessons need to be articulated for others to understand them, while their implication for (other parts of the) development have to be recognized in order to assess how they could be applied.

While feedback internal to the development is often of direct use to that development process, so it will often be applied rather quickly, feedback external to the development process often has no immediate use. It will have to be stored somewhere until it is needed, and be available when needed. This can be quit difficult as it often is stored too well and becomes inaccessible, or it is forgotten, as it had no immediate or clear utility. To avoid a loss of lessons learned they will have to <u>*become embedded in development behavior of individuals and organizations*</u>. This is the fourth building block of social learning in technology development.

An illustration of feedback during development can be found in the activities of the IBT (a Dutch acronym for introduction support team) during the development of VUIST. The IBT was established during the first

stage of development and its task was to facilitate the introduction of this new technological system into the RNLA, and was filled by artillery officers of the RNLA development team. As IBT they started with training the teachers of the fire support education and training center (OTCVUST) and helped them with the building of a curriculum for learning VUIST. Yet they also maintained contact with operational artillery units and helped them to prepare them for the introduction of VUIST. They helped those units with the required reorganization, familiarization, and during field exercises with VUIST. At the same time these officers were members of the RNLA development team directly involved in the development of VUIST. This meant that the members of the IBT could feed user experiences back into the development process, and at the same time feed users an understanding for the functionality's and (im)possibilities of VUIST.

The efforts of the IBT were much appreciated by the RNLA command and by operational VUIST users, and provided useful insights to the development of VUIST with regard to alignment. However, despite its overall success and utility in development of information systems for C2, the creation of an IBT type team hasn't become embedded in the RNLA (yet). If such a team is established this is done on the basis of individual preferences. Of course any organizational change depends ultimately on individual human behavior, but for the moment there is no organizational structure that supports the use of IBT type teams in the development of C2 information systems. In more general terms this means that there is as yet no infrastructure within the RNLA development community that facilitates and supports feedback processes in the development of information systems. As such it forms an internal barrier against the development of effective technology in support of C2.

This example can be seen as an example of feedback about the content of development.

4.0 A FRAMEWORK FOR ASSESSMENT OF SOCIAL LEARNING IN TECHNOLOGY DEVELOPMENT

So far my answer to the question posed in section one was based on case histories and philosophical discourses in TA. Now these will be translated into an instrument that can be used in the practice of current and future developments of technology; *a framework for social learning in the development of technology*[7].

The purpose of this instrument is the assessment of learning in technology development. In this way it provides an instrument that improves our understanding of, and practice in, how to develop effective technology. In my dissertation I explain how this framework provides insight into the social variables that facilitate or hinder learning in technology development or that facilitate/hinder the embedding of lessons learned. For the purpose of this paper I will focus on the locations in the development process where learning takes place and where an assessment of learning could prove critical for the success of technology development. So far I have identified five locations (or stages) in technology development where technology assessment and thus of social learning is critical to developing effective technology in support of C2. These locations are:

1) the expectations (visions) of technology in a future C2;
2) the specifications of requirements;
3) the choice of an appropriate partner in technology development;
4) the process of technology development;
5) the embedding of lessons learned, and is closely related to organizational learning.

[7] The name of the instrument is provisional, and may change during the writing of my dissertation. For the moment the name contains a set of elements that describe the aim or usefulness of the instrument.

In the remainder of this paper I will focus on the first and fourth locality because they provide a meta-structure or architecture for finding and placing other localities, and because they provide a useful context to describe the role the COBP could have for social learning in the development of C2 technology. This meta-structure is represented in figure (2). In the next paragraphs these locations and their relevance to technology assessment will be described, and will be followed by a discourse on the role of the COBP in this framework for social learning.

4.1 The Assessment of Expectations of Technology in a Future C2

Why is the assessment *of the expectation or vision of technology in a future C2*important? Firstly, through such a vision we create a cognitive framework that guides our thinking, decision making and actions in the development of technology. If this vision is not related to a thoughtful appreciation of future operational requirements and of technological possibilities to fulfill them, then the development of technology may not result in effective support for C2. And secondly, the introduction of technology will have certain consequences for C2 and its environment. These consequences are already implied or present in our expectations of a future C2 and can therefore be explored. If we ignore these consequences until a later stage in development it may be impossible to mediate or negate them in practice.

How can we assess our expectations or visions of technology in a future C2? To assess our expectations we need to bring them in the open and let others (developers, potential or expected users, stakeholders) see and comment on them. In this way we can acquire the most complete understanding on the practicality of our expectations. By bringing it in the open we are forced to be explicit and specific, and therewith provide the material that can and needs to be assessed. From this assessment we can learn if our expectations are practical and if they indeed represent a goal we want to achieve. In effect we need to articulate operational user-requirements, technical capabilities, their alignment and, furthermore, we need to reflect on them and on the possible impacts of technology on C2. To be effective this assessment requires without doubt a sound understanding of the reciprocal relationships between the humans, organizational infrastructure and technology in C2 [Elzen, Ensenrink and Smit 1996; Callon 1992]. This holistic approach is necessary because a change in one element will affect the other elements. In the past many developments of technology have gone awry because the reciprocity of these relations were not taken into account [Mandeles et. al. 1996; Rip et al. 1995], which meant that relevant consequences were left out of the assessment and subsequent development[8]. Of course not seeing them didn't mean they were not there, they were found in practice, but by then their impact could not be avoided.

Also the assessment of expectations will need to be an iterative process. Earlier we established that we do not know all at the start of a development process, and that we need to learn. This means that as we develop the technology, we will learn more about the process and object of development. These lessons most likely will improve our understanding of the technology in a future C2. Therefore the assessment of expectations of technology in a future C2 will have an iterative nature, if only to check if the development process is still aimed at the desired and intended goal, namely effective support of C2.

Figure (2) represents a graphical representation of the meta-architecture for assessment of social learning in the development of technology.

[8] Experience from many decades of TA have proven that, without the understanding and inclusion of these reciprocal relationships, the assessment or development of technology will fail to deliver effective technology [Smits and Leyten 1991; Callon 1986; Law and Callon 1988; Håkansson 1987] This is because changes in one element of the relationship will affect the other elements. If the reciprocal nature of these relationships is overlooked, unseen but actual consequences will result in a mismatch between human behavior, organizational behavior and technology. In military terms: it will incur friction as an organic part of C2.

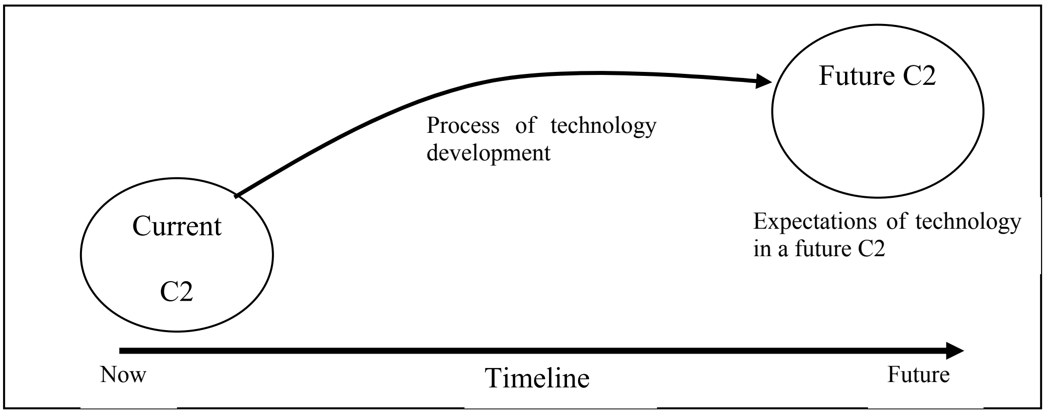

Figure 2: Meta Architecture for Social Learning in Technology Development.

4.2 The Assessment of the Process of Technology Development

The process of technology development, why is assessment of social learning in this location important? It is important because most often we do not know the route to success in advance and therefore need some cues to decide if the route we have taken will lead us to the target we intend to achieve. Social learning in the locality 'expectation of technology in a future C2' provides us with cues about the goal we want to reach and consequences we want to avoid in technology development. Finding cues in the course of technology development is largely depended on interaction patterns between developers, users, principals and other stakeholders. If these patterns facilitate or allow social learning to take place these cues will surface in the practice of social learning. If these patterns hinder or do not allow social learning to take place many cues will remain hidden and success will be depended solely on luck or on some bright individuals going against al odds (and organizational constraints). As the development follows its course and learning takes place, changes in user-requirement, technological capabilities, technological impacts or development methods may require a re-assessment of the aiming point or may require a re-assessment of the development path followed so far. This may require backing up a little and choosing a different route.

What does this mean in practice? It means that we need to assess if the development strategy is in line with the intended aim as articulated in the (assessed) vision of technology in a future C2. This involves amongst others an assessment of utility of the design-tools and procedures used to develop the technology, of the methods used to achieve alignment between user-requirements and technical capabilities; and of the methods used to discover impacts of our decisions made in technology development. Of course articulation of user requirement and technical capabilities remain central issues. Implicitly this means that articulation is not a one-off, static activity, but rather an iterative dynamic activity. Good development practice will try to facilitate this iterative process.

5.0 THE ROLE OF THE COBP IN THE ASSESSMENT FRAMEWORK FOR SOCIAL LEARNING IN TECHNOLOGY DEVELOPMENT

How does the COBP fit into all of this? The primary role of the COBP in the framework for social learning are located in the assessment of expected future C2, and is related to the fundaments for achieving effective technology in C2, namely alignment and impact assessment. It does however also have some secondary roles that merit attention. These secondary roles are related to the provision of rigor and iteration in assessment, and to the embedding of lessons learned.

5.1 The Primary Role of the COBP in Social Learning

The assessment of our expectations of technology in a future C2 is crucial to the development of effective technology. However, it is not often that it is performed well. If the NATO code of best practice for C2 assessment would be used in the assessment of our expectations of technology in a future C2, it could provide a structure that almost forces one to perform the assessment well (i.e. well structured, rigorously and in iterations). More specifically it could be useful in the articulation of user requirements and impact assessment.

Firstly, its usefulness in the articulation of user-requirements. Despite our advances in C2 research and development, C2 to a great extent remains a diffuse knowledge domain. This makes the articulation of C2, i.e. translating our understanding of C2 into C2-requirements, more difficult than articulation of requirements already is. Yet without it we cannot develop effective technology to support C2. The COBP could help us to overcome this dilemma, by using it as a method to find those issues in the C2 domain that need to be articulated. Secondly, when assessing the impact of technology in C2 we are interested in how it affects C2 behavior and its environment. In order to assess the impact of technology on C2 we need to understand the dynamics of C2, without it assessment will be impossible. At the moment our understanding of C2 dynamics does not present a comprehensive whole, but rather consists of a whole range of dispersed knowledge, situated in a variety of individuals, institutions and disciplines. The COBP could provide a guide that facilitates a convergence of C2 knowledge that will enable an effective impact assessment of technology in the C2 domain.

Why could the COBP be used in this manner? Well the COBP pays particular attention to problem structuring and forces the analyst (who might also be a user or a developer etc.) to become very specific in the issues that are relevant to a certain problem. It states for example that "the problem is not formulated until the assessment team has <u>specified each aspect of the problem</u>" [COBP 2002] (underlined by Swentibold Stoop). Also the COBP explicitly uses an iterative approach C2 assessment. This allows for the inclusion of new knowledge and experience in the course of assessment. In this way it stimulates learning and facilitates more detailed specification of C2 requirements. Furthermore it guides developers, technology users and others using the COBP to the discovery of measures to assess the impact of technology on the performance of C2. For instance it provides guidelines for using scenarios to assess the impact of technology in a future C2 in a variety of operational environments. Though as yet, the COBP is more oriented on the external effects of C2 change and less suited to the discovery of impact on the internal functioning of command post.

5.2 The Secondary Roles of the COBP in Social Learning

Here I want to briefly mention two issues – rigor and embedding of lessons. The iterative assessment structure of the COBP enforces, or at least facilitates a rigorous approach to assessment, ensuring comprehensiveness. Yet it does more, through its chapter on risk and uncertainty it facilitates reflection on the tools and methods of assessment that are used in the assessment of C2. In this way it facilitates discovery and learning of appropriateness of the process and procedures followed. This may also facilitate, and hopefully stimulate, reflection on solutions and solutions strategies used in technology development.

The COBP is based on lessons learned in the practice of C2 assessment, so it represents an example of embedding lessons learned. As it is aimed at analysts involved in C2 research and development in NATO and beyond, this example could reach far and wide in the C2 R&D community. The intention to revise it iteratively also furthers the aim of embedding, as does the presentation of iterations as method of best practice in C2 assessment. If this aim of the COBP is more widely understood and implemented, for example in the framework for social learning in technology development, it could facilitate the embedding of development lessons in individuals, institutions and disciplines.

5.3 Some Reservations about the Role of the COBP in Social Learning

Finally, I want to present some reservations about the utility of the COBP in the framework for social learning in technology development. The COBP is sometimes too much focused on specific variables and quantitative analysis. Effective articulation of C2 issues may require the inclusion of more qualitative and holistic assessment of C2, especially with regard to the reciprocal relationships between "*human behavior–organizational behaviour – technology*" in C2[9]. The need to understand these reciprocal relationships becomes more and more recognized in the C2 research and development community. Therefore I expect that we will see improvements in this area in future revisions of the COBP. However, for the moment other assessment tools like CTA [Smit and van Oost 1999] or the perspective of boundary work [Gieryn 1999; Gunston 2001] offer more fruitful methods to cover the assessment of these relationships.

The COBP does stress that the assessment team needs access to matter experts, and in its introduction recognizes the need for a comprehensive assessment. But probably because it is still mostly oriented towards operational research (OR) analysts, it as yet does not provide measures to make the required interdisciplinary teamwork. Effective interaction between different subject matter experts requires specific skills and approaches that require them to step outside their respective cognitive frames to develop a common cognitive frame. This could be achieved by mediators experienced in developing and using such a common frame or by educating and training respective experts. To be fair, the COBP mentions this need, and overall the COBP is a great improvement. Yet from a social learning perspective, the relevance of this issue merits a more specific address than it currently has in the COBP.

6.0 SUMMARY

This paper was based on the preliminary findings from ongoing dissertation research on developing effective technology in support of C2. In this dissertation the thesis is that social learning is crucial to the development of effective technology. It is further recognized that learning does take place but poses that this isn't translated into a general understanding of dynamics of technology development. Consequently technology development too often results in less than effective technology in C2. This may seem outrages, but the examples of VERDAC and VUIST prove otherwise. Furthermore they showed that the concept of social learning provide an explanation for the failure and success of VERDAC and VUIST respectively.

Social learning involves four activities, namely articulation, reflection; feedback and the embedding of lessons learned. These activities take place in the interaction between actors (expected users, developers, and other stakeholders) in development of technology. The social variables that affect the occurrence of social learning in this interaction are the current topic of my dissertation research.

To identify localities in technology development were social learning is essential I have developed a "framework for social learning in technology development. So far I have identified five localities where this is the case. In this paper I have described two of them, namely the 'expectations of technology in a future C2'; and the 'process of development'. Their relevance is twofold. Firstly, together they provide architecture for finding and placing other localities. Secondly, the first provides a frame of reference for decision making in the development of technology and the second a frame of reference for assessing whether the development is still on course.

[9] For completeness I should note that I myself am a member of the sas-026 panel and co-author of Chapter 6 "Human Organization Factors" in the (revised) COBP. Revising the COBP was a collaborative effort and achieved many improvements over the original COBP. Even in the area of human and organizational issues in C2. Yet on some issues in this area the work hasn't yet finished and will provide a challenge for future work on the COBP.

The role of the COBP in technology development is located in assessment of our expectations of technology in future C2. Its primary role is finding C2 issues that need to be articulated, and to support the impact assessment of technology on C2. Yet some secondary roles can also be identified, namely its support for rigor, iterations and embedding of lessons learned. Still, there are also some reasons for caution. The COBP as yet, is not well suited to assess the internal workings of C2. Also, currently it doesn't provide enough guidance to the application of multi-disciplinary assessment teams that are required to assess the complex range of C2 issues.

Overall, the COBP and CTA provide complementary tools and insights that are relevant to the development of effective C2 technology. In this paper I have stated the case from the perspective of CTA. However from the COBP perspective CTA could play an important role in the technology assessment and the assessment of the reciprocal relation with human and organizational issues, both in current and in future C2 problems.

And last but not least, both the COBP and CTA do not provide Utopia. They do provide effective means to improve our understanding of C2 and technology development respectively. Together they provide the tools to overcome the challenges to effective technology development in C2.

7.0 REFERENCES

Callon, M. (1986), "The Sociology of an Actor-Network: The case of the Electric Vehicle", In: Callon, M., Law J. and Rip, A (1986), "Mapping the dynamics of science and technology", The MacMillan Press Ltd.: London.

Callon, M. (1992), "The Dynamics of Techno-Economic Networks", In: R. Coombs et al (1992), "Technological change and company strategies", Academic Press: London.

COBP (provisional) 2002, "The NATO Code of Best Practice for Command and Control Assessment".

Elzen B., Ensenrink, B. and Smit, W.A, (1996), "Socio-Technical Networks: How a technology studies approach may help to solve problems related to technical change", In: *Social Studies of Science, vol 26*, pp. 95-141.

Gieryn, T. (1999), "Cultural Boundaries of Science: Credibility on the Line", University of Chicago Press: Chicago.

Guston, D.H. (2001), "Boundary Organisations in Environmental Policy and Science: An Introduction. In: Science, Technology & Human Values", Journal of the Society for Social Studies of Science, volume 26, number 4, Autumn 2001, Sage Publications.

Law, J., and Callon, M. (1988), "Engineering and Sociology in a Military Aircraft Project: A Network analysis of Technological Change", In: *Social problems, vol 35, nr 3*.

Håkansson, H. (ed.) (1987), "Industrial Technological Development. A Network Approach", Routledge: London.

Fiol, C.M. and Lyles, M.A. (1985), "Organizational learning", In: *Academy of Management Review,* jrg 10, NR 4, pp. 803-813.

Jasanof, S., Markle, G.E., Petersen, J.C. and Pinch, T. (eds.) (1995), "Handbook of Technology Studies", Sage: Thousands Oaks, CA.

Mandeles, M.D., Hone, T.C. and Terry, S.S. (1996), "Managing Command and Control in the Persian Gulf War", Preager: West Connecticut, London.

Rip, A., Misa, J.T. and Schot, J. (1995), "Managing Technology In Society. The approach of Constructive Technology Assessment", Printer Publishers: New York and London.

Shrivastava, P. (1983), "A typology of organizational learning systems", In: *Journal of management studies*, NR 2, pp. 7-28.

Smit, W.A., and van Oost, C.J. (1999), "De Wederzijdse Beinvloeding van Technologie en Maatschappij : een Technology Assessment-benadering", Cotinho: Bussum.

Smits, R. and Leyten, J. (1991), "Technologie Assessment: Waakhond of Speurhond? Naar een integraal technologiebeleid", Dissertation at the University of Twente, Kerckebos b.v.: Zeist.

Tjekema, S (1993), "Profiel van de Leerende Organisatie", Centrale reproductie-afdeling Univeristeit Twente.

TRADOC (1997), In: URL http://www.fas.org/irp/agency/army/tradoc/.

Wijdemans, P.C.J. and Mencke, J.B. (1995), VUIST-1, Vuursteun Informatie Systeem, Proefsysteem, Borrias Planodruk: Zwolle.

8.0 LIST OF ACRONYMS

C2	Command and Control
COBP	Code Of Best Practice (NATO code of best practice for C2 assessment)
CTA	Constructive Technology Assessment
DOTMLS	Doctrine, Organization, Training, Materiel, Leaderships, Soldiers
ICT	Information and Communication Technologies
NATO	North Atlantic Treaty Organization
OR	Operational Research
RNLA	Royal Netherlands Army
STS	Science and Technology Studies
TA	Technology Assessment
VUIST	Fire support information system ("Vuursteun informatie systeem")
VERDAC	Improved Digital Artillery Computers ("Verbeterde digitale artillerie computer")

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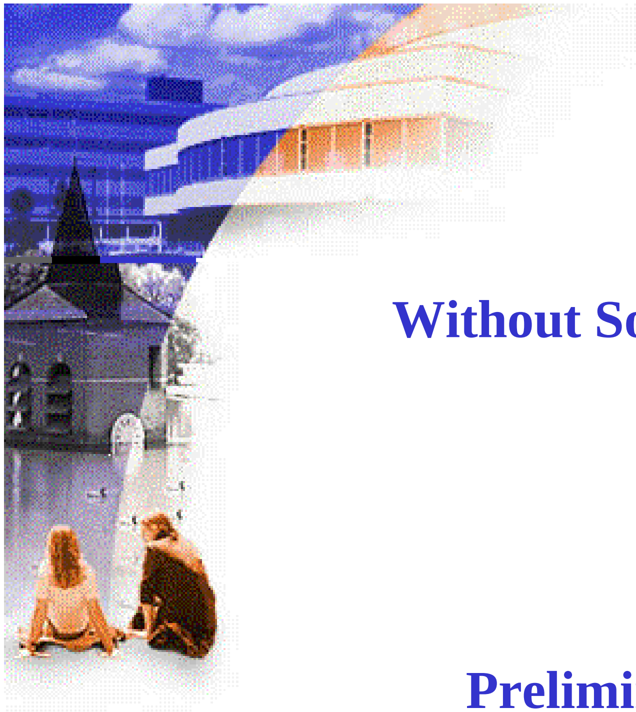
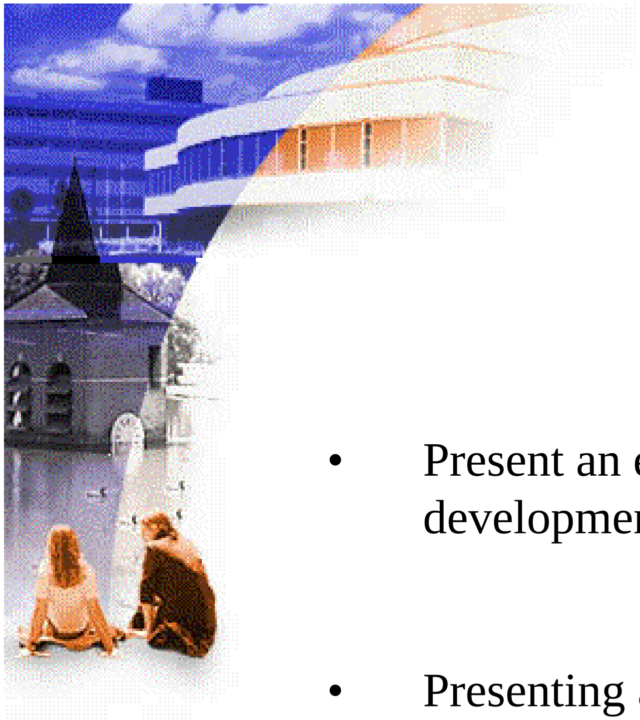


Without Social Learning No Development of Effective C2 Support Technology

Preliminary findings from ongoing Ph.D. Research

Drs. Swentibold Stoop

University of Twente, Royal Military Academy, TNO Physics & Electronics Laboratory



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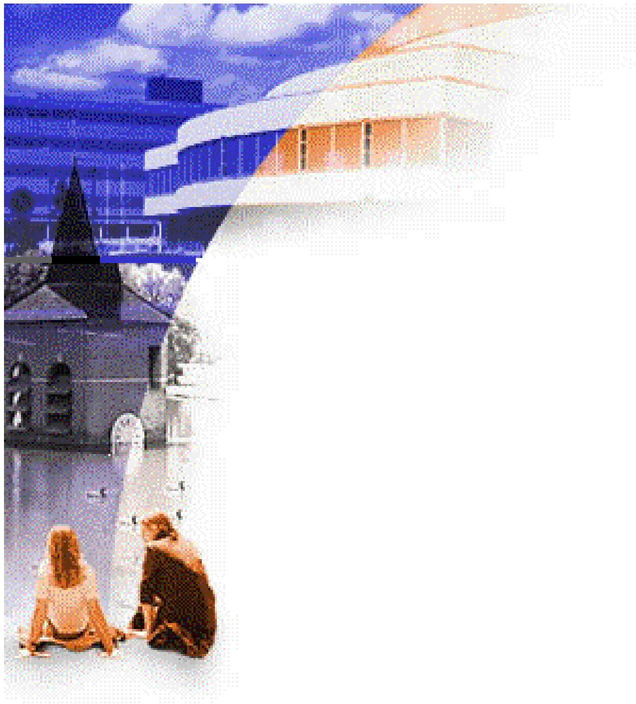
SETUP

- Present an example highlighting key challenges in technology development
- Presenting a the tools to overcome the challenges more successfully
- Present the role of the COBP in the framework for social learning in technology development in support of C2.



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EXAMPLE
Requirements?

Future C2

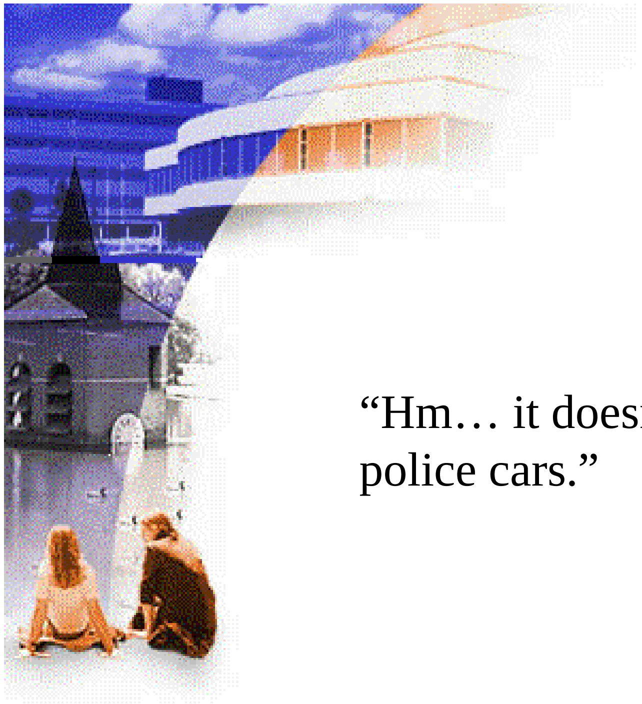
Arrive quickly at the scene of an incident by: an information system with GIS & GPS

Problems with arriving on time at scene of incident

Current C2

Timeline

T = 0



EXAMPLE

OEPS !

“Hm… it doesn’t fit in police cars.”

“And is not man-portable”

Future C2

Current C2

“But it has GPS and GIS!”

Timeline

T = 0

EXAMPLE

Getting requirements right.

(Or to achieve alignment between user-needs and technology)

(Users) ⟷ **(Developers)**

Articulation of :
- User-Requirements
- Operational context

Articulation of :
- Technical Capabilities
- Developing Environment

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EXAMPLE

Getting requirements right.

(Or to achieve alignment between user-needs and technology)

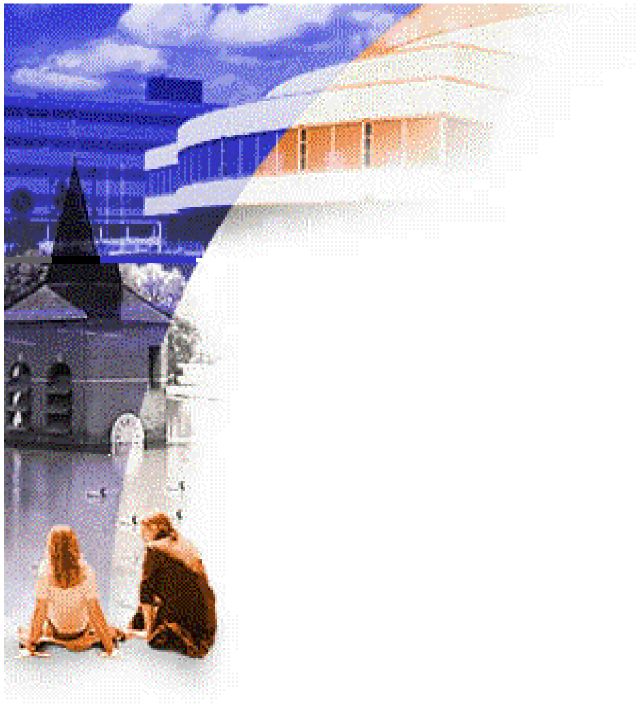
(Users)

(Developers)

Articulation of :
- User-Requirements
- Operational context

Articulation of :
- Technical Capabilities
- Developing Environment

Requires effective communication!



EXAMPLE

Success!!

Future C2

Current C2

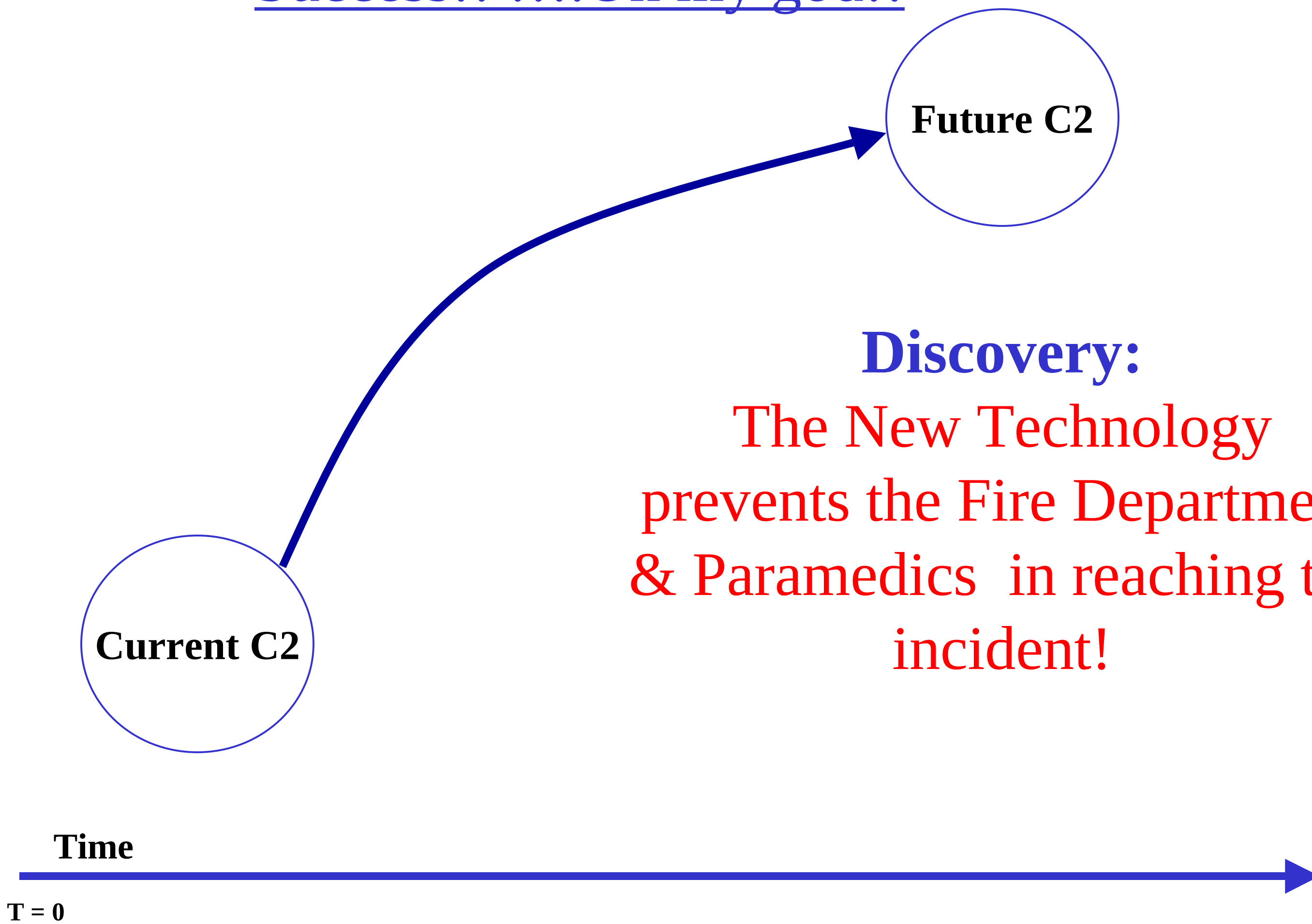
1) Real time Presentation of own positions
2) Real time Presentation position of incidents
3) Route Clearance for police cars

Time

T = 0

EXAMPLE

Success!! ….Oh my god!!



Discovery:

The New Technology prevents the Fire Department & Paramedics in reaching the incident!

Problem Structuring

Three key challenges in the development of ICT support for C2

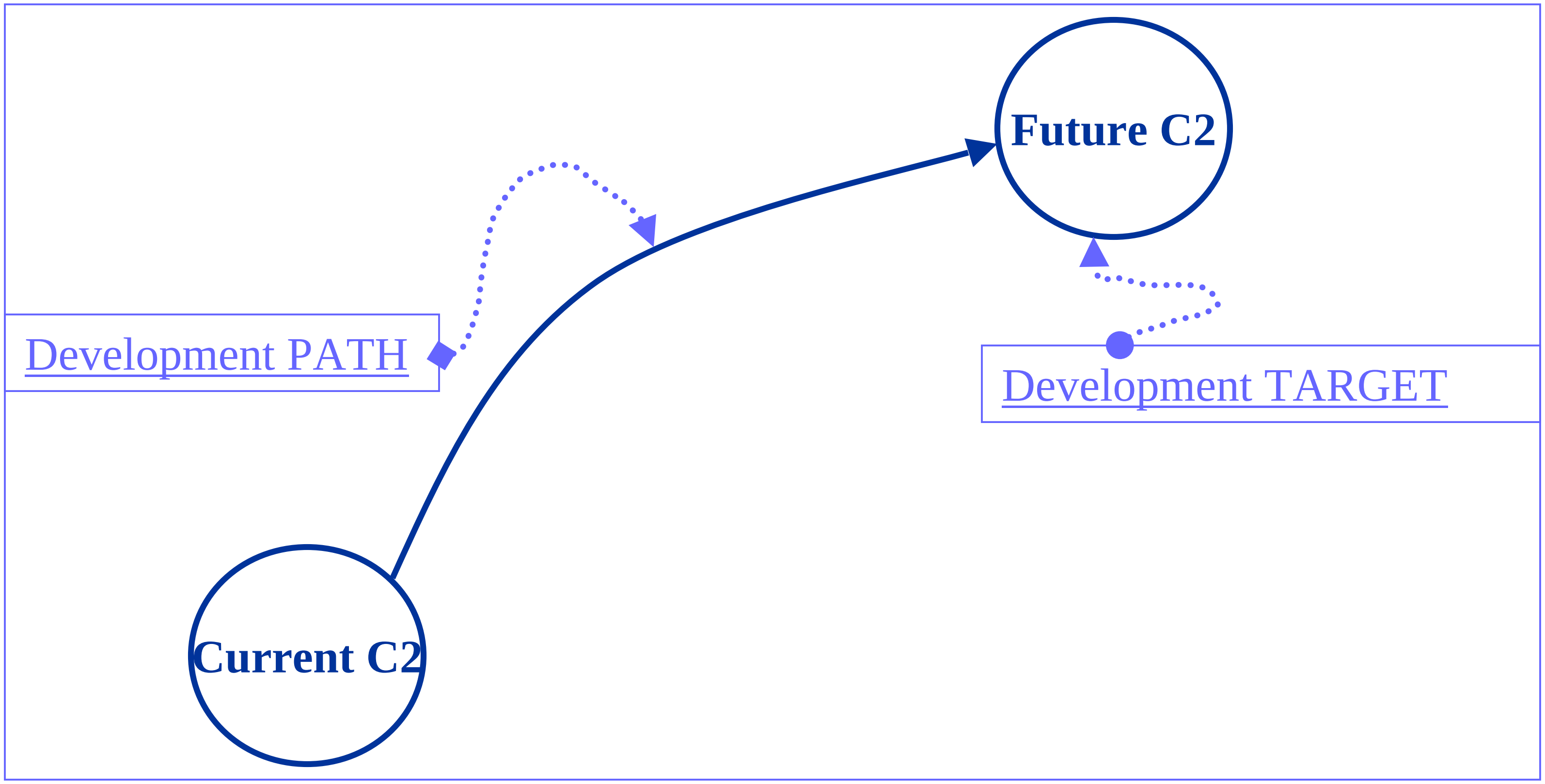
- ❑ Alignment between user-needs and technical capabilities.
- ❑ Timely recognition of impacts.
- ❑ An understanding of the reciprocal relationship between technology, organization and humans

Learning on these issues has too often not been efficient,
resulting in a huge waist in resources and none too effective technology

The assessment framework for social learning provides
a guide to (more) successful learning,
and thus to developing technology that is (more) effective in supporting C2

Solution Space part 1

Where social learning should take place



Graphical representation of framework

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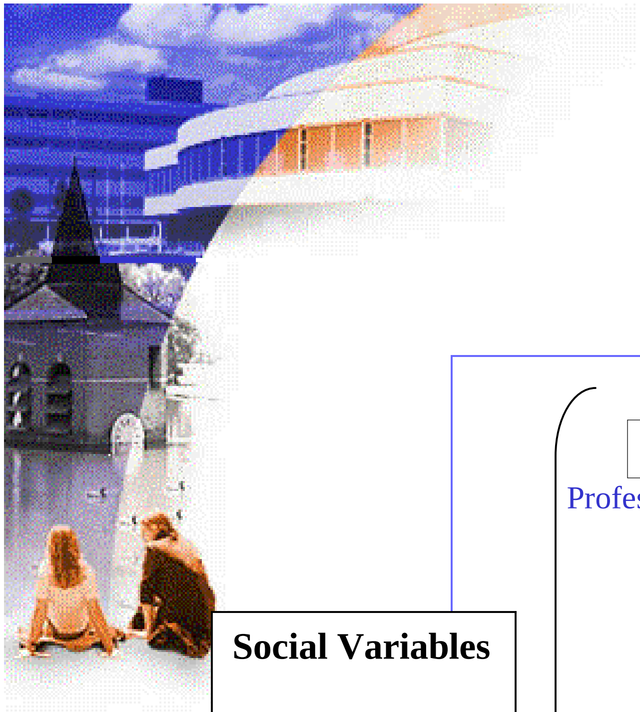
Solution Space part 2

What needs to be assessed?

- **Articulation:** To be explicit and specific about needs, capabilities and impact.
- **Reflection:** To think about assumptions underlying and about consequences of concepts, decisions and actions in technology development
- **Internal Feedback:** Here the transfer and application of lessons learned in the development process
- **External Feedback:** Here the transfer and embedding the lessons learned into (parent) organizations and institutions

The building blocks of social learning



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Solution Space part 3

When does social learning occur?

Social Variables

- Language
- Trust
- Environment
- Culture
- Geography
- Formats

Ethics level
Professional attitude, conduct.

Affect level
Expression of beliefs, expectations, feelings.

Procedure level
Articulation, Reflection and Feedback, Embedding

Content Level
Technology, Requirements, Alignment& Impact Assessment

Levels of communication enabling social learning

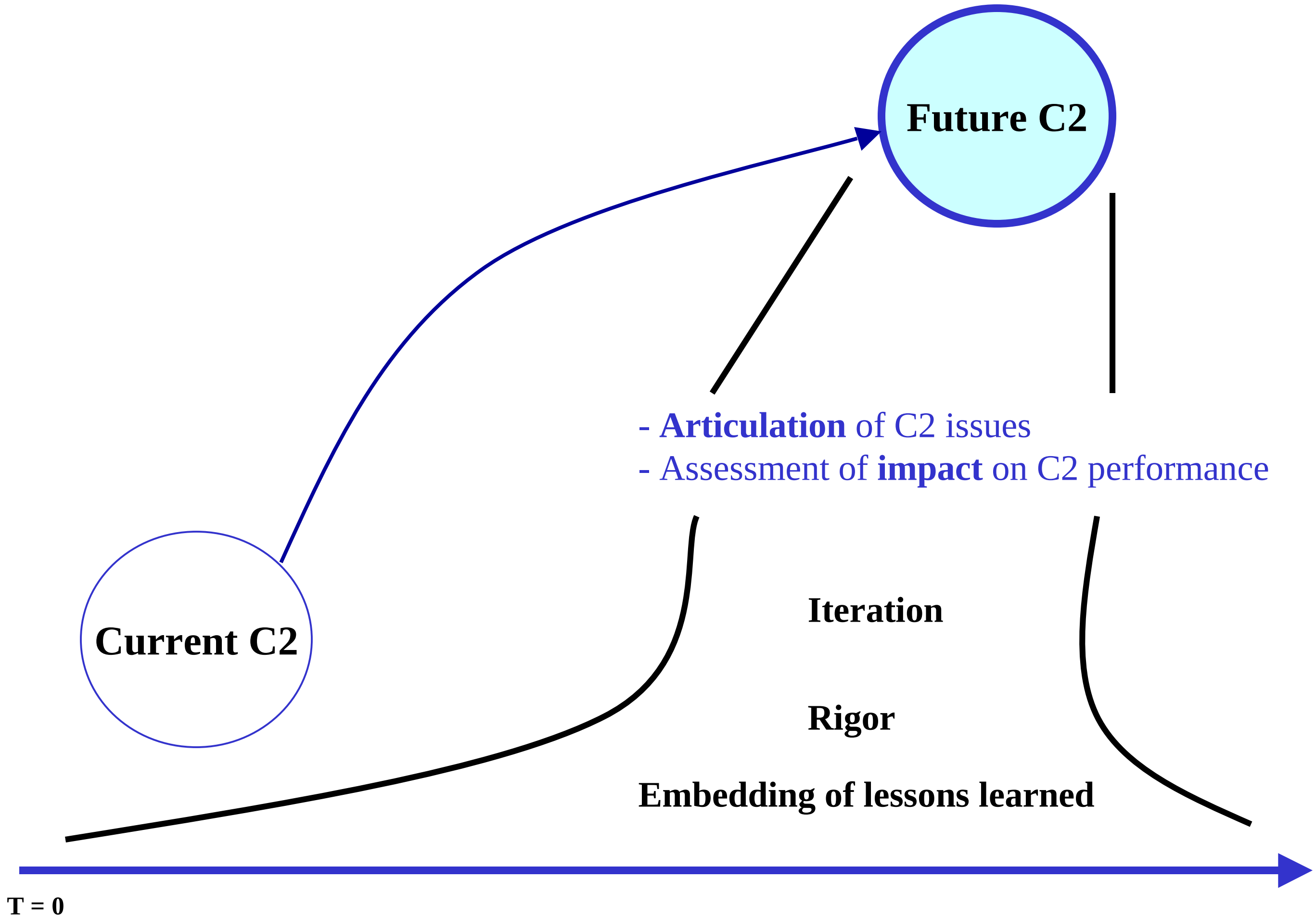
An Empirical Example

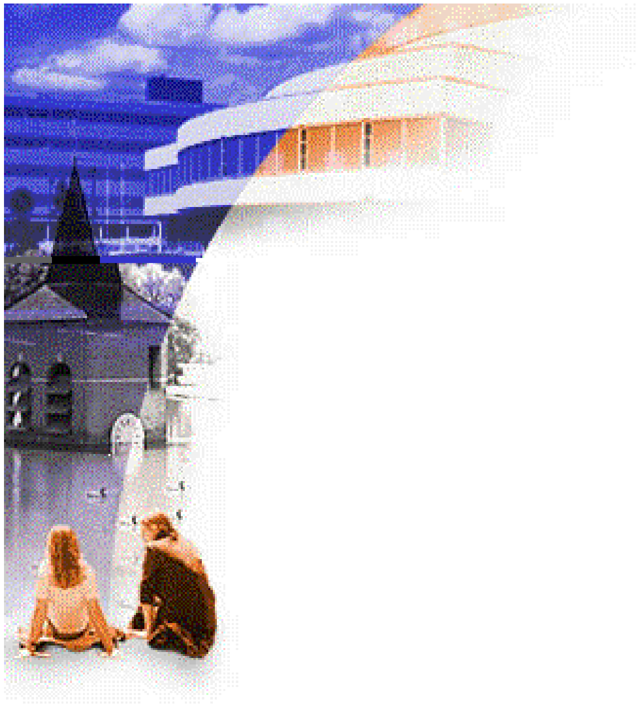
The role of articulation and reflection in the resolution of technical challenges

ID	Comments	Developer Response	Discussion Results
IMP 076	New requirements for this improvement Are expected in the SRS	The requirements regarding this IMP are fully covered in the GPS IRS	Ok
SFR 301	Target is default There is a situation in which the Watch officer expects command data quality but because of implementation of the solution of SFR 201 this is not the case. So from *operational point* of view it is required that Persuit Orders can be given in such a case. A solution must be found to solve this issue (discussion)	To be discussed	Developer will investigate this issue. **AI 2.**
IMP 033	It might be wise to generate a warning which informs the operator about the fact that the Incident data is no longer valid (discussion)	Currently, the system does not display any warning upon invalidation of FDT due to changes in any other data	No warning will be issued
IMP 051	Police Dept. refers to the reaction to SW 4 questions of 16-06-99 and still has the opinion that there is no operational reason to implement this improvement	To be discussed	Developer will cancel the implementation of this improvement

Application of social learning in practice

The role of the COBP in social learning





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QUESTIONS?

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